EFFECTS OF DIAPHRAGMS IN I-BEAM BRIDGES

BY

BENJAMIN CHIH-FANG WEI

B.S., St. John's University, 1945
M.S., University of Illinois, 1948

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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EFFECTS OF DIAPHRAGMS IN I-BEAM BRIDGES

The object of the investigation is to obtain a better understanding of the action of diaphragms in I-beam bridges. The I-beam bridge, consisting of a concrete roadway slab continuous over steel stringers, has found widespread application for highway bridges because of its simplicity of design and ease of construction. The diaphragm which may be in the form of an angle, a channel, an I-beam, or a built-up section is a transverse framing device, which is added to the structure with the primary aim of improving the distribution of load to the supporting beams.

The data contained in the thesis are based entirely on analytical considerations and apply to simple-span right bridges consisting of a continuous slab supported by five uniformly spaced parallel beams of equal stiffness, with diaphragms framed transversely in different positions between the beams. The bridges considered have beams in the direction of traffic. The flexibility of the beams is taken into account in the analyses.

The problem of the I-beam bridge with diaphragms is statically indeterminate to a high order. The exact solution to the problem is too complicated to be practicable. In this thesis the basic principle presented for the solution of the problem is to replace the action of the diaphragms in the structure by a set of equivalent forces acting at the points of intersection of the diaphragms and the beams. Here the simplifying assumption is made that the connections between the diaphragm and beams are fully effective. The problem is then reduced to one of finding moments in a bridge without diaphragms but subjected to additional forces. The analytical solution of a large number of simple-span right bridges, consisting of a slab supported by five identical parallel beams but without diaphragms, has previously been made by using a distribution procedure

described in Bulletin 304*, and numerous influence tables for moment and deflection in beams have been reported.** These tables can be used for the calculation of influence coefficients for moment in beams in the same structure with the addition of diaphragms. A number of tables are lacking for computing the data presented. The writer has separately analyzed these additional structures by using the same procedure as used in Bulletin 336 and the results are given in Appendix A.

To facilitate the analyses a load is generally broken up into its symmetrical and antisymmetrical components. The two components are then superposed to obtain the final effect of the load. This procedure has the advantages of reducing the number of simultaneous equations to be solved and of treating several cases in one operation of calculation.

Analyses for a total of eighty-five different structures were made. In general, the maximum moments are determined in the beams for different positions of a concentrated load on the structure. Bridges with diaphragms of various stiffnesses and framed at midspan, each third-point, each quarter-point, midspan plus quarter points, and for one case at points 1/12 of the span from midspan are considered. Tabulated influence coefficients for moment in beams are given in Appendix B for a group of these structures having various proportions and different relative stiffnesses of beams and slab. Maximum moments in the beams due to standard truck loading are determined for the same structures with spacing of beams between the limits of 5 to 8 ft. These results are also given in Appendix B in tabular form.

From the results of analyses studies and comparisons are made to investigate the effects of the following variables on the action of diaphragms in the structure: (a) relative stiffness of diaphragm to that of each beam, (b) the position of diaphragms in the structure, (c) relative stiffness of beams

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*N. M. Newmark, "A Distribution Procedure for the Analysis of Slabs Continuous Over Flexible Beams," University of Illinois Engineering Experiment Station, Bul. 304, 1938

**N. M. Newmark and C. P. Siess, "Moments in I-Beam Bridges," University of Illinois Engineering Experiment Station, Bul. 336, 1942

to that of slab, (d) relative dimensions of the bridge, and (e) the type and position of loading. The criterion of comparison is in general the maximum moment in beams produced by unit loading or 4-wheel loading, with particular emphasis laid on the latter to simulate the actual loading condition. Certain rules which should lead to favorable use of diaphragms in I-beam bridges under various conditions are formulated.

The results of the analyses are generally applicable to structures with concrete T-beams and diaphragms. The application of the results to continuous and skew I-beam bridges is also discussed briefly.

VITA

Benjamin Chih-Fang Wei was born on July 2, 1926, in Ningpo, Chekiang, China. After graduating from St. John's Middle School in 1943, he entered St. John's University, Shanghai, China, and received from that institution the degree of Bachelor of Science in Civil Engineering in September 1945. From October 1945 to March 1946, he was a cadastral surveyor for the Bureau of Land Administration of the Shanghai Municipal Government. He was then connected with "National Architects and Engineers", Shanghai, China, where he worked on designs of residences, bank buildings, warehouses, and wharves from April 1946 to August 1947. His practical experience in United States consists of designing of industrial plants during the summer of 1949 while he worked for R. H. Maveety, Consulting Engineer in Chicago, Illinois.

He began his graduate study at the University of Illinois in September 1947 and received the degree of Master of Science in June 1948. In September 1949, he was appointed Research Assistant on the Reinforced Concrete Slab Investigation at the University, which position he now holds.

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